Cite this as: Muhammad WAQAS, Yoon-Ha KIM, Abdul Latif KHAN, Raheem SHAHZAD, Sajjad ASAF, Muhammad HAMAYUN, Sang-Mo KANG, Muhammad Aaqil KHAN, In-Jung LEE, 2017. Additive effects due to biochar and endophyte application enable soybean to enhance nutrient uptake and modulate nutritional parameters. *Journal of Zhejiang University-Science B (Biomedicine & Biotechnology)*, 18(2):109-124. http://dx.doi.org/10.1631/jzus.B1500262

Additive effects due to biochar and endophyte application enable soybean to enhance nutrient uptake and modulate nutritional parameters

Key words: Phytohormone-producing endophytic fungi; Nutrients uptake; Assimilation; Nutritional quality; Soybean

Research Summary

- Combined application of biochar (hardwood derived) and a phytohormones producing bioactive endophyte (*G. geotrichum* WLL1) showed additive effect

- Assimilation and uptake of basic, macro, and micro- nutrients in soybean were enhanced

- Functional amino acids and nutritional characteristics were improved

Innovation points

- Combined application of biochar and *G. geotrichum* significantly improved macro - and micronutrient dynamics in the substrate, root, and shoot of soybean

For example, Table 1. shows macro- and micronutrient dynamics in soybean shoots grown in the presence and absence of biochar and the phytohormone producing endophytic fungus, *G. geotrichum*, when applied individually and in combination

Treatment	P (mg/Kg)	K (mg/Kg)	S (mg/Kg)	Ca (mg/Kg)	Mg (mg/Kg)	Mn (mg/Kg)	Fe (mg/Kg)	Cu (mg/Kg)
Control	14.63±0.01c	63.60±0.96c	13.77±0.71c	44.29±0.74b	16.44±0.11c	0.37±0.34c	0.59±0.08d	ND
G. geotrichum	19.47±0.78b	90.32±0.37b	17.90±0.11b	29.32±0.21c	13.12±0.55d	0.25±0.83d	0.68±0.36c	ND
B.C	23.44±0.88a	105.00±0.44a	20.32±0.96a	51.06±0.09a	22.20±0.86a	0.44±0.36a	0.81±0.03a	ND
B.C+ *G. geotrichum*	24.87±0.69a	107.20±0.62a	22.60±0.90a	43.15±0.69b	19.71±0.81b	0.41±0.25b	0.75±0.61b	ND

P=Phosphorus, K=Potassium, S=Sulfur, Ca=Calcium, Mg=Magnesium, Mn=Manganese, Fe=Iron, Cu=Copper, ND= Not detected/ Not determined in the samples. Each value is the mean ± SD of six replicates from three independent experiments. The data were analyzed by ANOVA using SAS ($p < 0.05$). Values in a column followed by different letter(s) show the significant differences among treatments based on DMRT.

Innovation points

- Table 2. shows additive effect due to the combined application of biochar and phytohormone producing endophytic fungus, *G. geotrichum* enhanced biosynthesis of total sugar content, total phenolic content, and DPPH inhibition activity of soybean

Treatments	Total sugar contents (mg/g)	Total phenolic contents (mg/g)	DPPH inhibition activity (%)
Control	0.62 ± 0.02b	300.70 ± 5.13b	51.28
G. geotrichum	1.62 ± 0.32a	389.20 ± 8.30a	68.92
B.C	0.62 ± 0.15b	306.90 ± 4.10b	55.28
B.C+ *G. geotrichum*	1.71 ± 0.33a	407.50 ± 12.90a	73.34

Each value is the mean ± SD of six replicates from three independent experiments. The data were analyzed by ANOVA using SAS ($p < 0.05$). Values in a column followed by different letter(s) show the significant differences among treatments based on DMRT.

Innovation points

Conclusion

- Combined application of bioactive endophytes and biochar is recommended for environmentally-friendly agriculture